Spatial patterning, correlates, and inequality in suicide across 432 neighborhoods in Taipei City, Taiwan

Abstract (Max: 300 words)

More than half of the world's population now lives in urban areas. Understanding the spatial distribution of suicide in these settings may inform prevention. Previous analyses of the spatial distribution of suicide in cities were mostly restricted to Western nations. We investigated the spatial pattern of suicide and factors associated with its spatial distribution in Taipei City, Taiwan. We estimated smoothed standardized mortality ratios for overall suicide and suicide by sex/age group across 432 neighborhoods (mean population size: 5,500) in Taipei City, Taiwan (2004–2010) using Bayesian hierarchical models. A range of area-level characteristics including socioeconomic deprivation, social fragmentation, income inequality, and linking social capital were investigated for their associations with suicide mortality. Overall suicide rates were below average in the city center, whereas above average rates were found in some suburbs. The cartogram highlighted the concentration of suicide burden in the western area of the city. Male suicides demonstrated generally similar spatial patterning across age groups, while the geographic distribution of female suicides differed by age. After adjusting for other variables, two area characteristics were found to be associated with area suicide rates: the proportion of divorced/separated adults (rate ratio [RR] per one standard deviation increase =1.08, 95% confidence interval 1.01-1.16), an indicator of social fragmentation; and median household income (RR=0.80, 0.73-0.86), an indicator of socioeconomic deprivation. There was a 1.8-fold difference in suicide rates between neighborhood quintiles with the lowest and the highest median household income, with middle-aged males showing the largest gradient (3.2-fold difference). The geography of suicide in Taipei City showed spatial patterning and socioeconomic correlates distinct from cities in Western nations. There is a need for future research to better understand the correlates of change in the geographic distribution of suicide throughout the process of urban development.

Keywords: suicide, spatial analysis, socioeconomic characteristics, inequalities

1. Introduction

Suicide is a leading cause of premature mortality worldwide (World Health Organization, 2014). There are pronounced variations in suicide rates across countries (World Health Organization, 2014) and in different areas within countries, e.g. England and Wales (Gunnell et al., 2012; Middleton et al., 2004), Germany (Helbich et al., 2017a) and the United States (Trgovac et al., 2015). More than half of the world's population now resides in urban areas (United Nations, 2014). Recent studies, mostly from Western nations, revealed marked geographic variations in suicide rates within cities (Gotsens et al., 2013; Middleton et al., 2008). For example, in London, UK, high suicide rates were found to concentrate in the deprived city center (Middleton et al., 2008). Most of the world's largest cities are located in Asia (Satterthwaite, 2007); however, only few previous studies have investigated the spatial patterning of suicide in Asian cities such as Hong Kong, China (Fong & Yip, 2003; Hsu et al., 2015), and Seoul, South Korea (Yoon et al., 2015). It is expected that Asian countries will continue to experience massive urbanization in the coming decades (Satterthwaite, 2007) and some recent studies of suicide trend in China suggest diminishing positive impact of urbanization on suicide (Sha et al., 2017), underscoring the need to better understand the pattern of suicide in Asian cities.

Systematic reviews, largely based on studies conducted in Western nations, indicate that areas characterized by high levels of socioeconomic deprivation (e.g. high unemployment or high composite deprivation indices) have increased suicide rates (Cairns et al., 2017; Rehkopf & Buka, 2006). In addition to socioeconomic deprivation, social fragmentation (Congdon, 2004) has been developed as a concept based on Durkheim's theories of social integration (Durkheim, 1951) which postulates that reduced connectedness between individuals and society may increase population suicide rates. Indicators of social fragmentation have been shown to be associated with area suicide rate in previous studies (Collings et al., 2009; Congdon, 1996).

Over the past decades it has been suggested that income inequality has important additional influence on the level of social integration and health. A number of previous studies indicated the beneficial effects of low income inequality on health (Pickett & Wilkinson, 2015). Increased income inequality may contribute to social comparisons between individuals and result in a feeling of relative deprivation, a sense of unfairness, and in turn psychosocial stress that might contribute to increased risk of suicide (Hong et al., 2011; Machado et al., 2015). However, there has been relatively less research focusing on the potential influence of income inequality on suicide (Rehkopf & Buka, 2006), and previous studies were mostly from Western countries at relatively high geo-spatial level such as between countries or states (Andres, 2005; Minoiu & Andrés, 2008). In cities experiencing fast economic development, the rapid growth could be accompanied by a marked uneven distribution of wealth in the city. Therefore, the local level of income inequality may be an important determinant of suicide in such a setting. However, previous studies investigating the association between neighborhood levels of income inequality and suicide in cities are few (Hsu et al., 2015).

During the past decades the concept of social capital has received growing attention and has been theorized as an asset of social connections or resources at the individual or community level that may produce and promote social profits (Putnam, 2000), including positive health outcomes (Murayama et al., 2012). Social capital may also contribute to emotional and material support, and recent studies suggested a protective effect of high social capital against suicide (Okamoto et al., 2013; Smith & Kawachi, 2014). Social capital is originally categorized into 'bonding' and 'bridging' types. Bonding social capital refers to relationships between homogeneous groups who share similar sociodemographic or socioeconomic characteristics, while bridging social capital refers to relationships between heterogeneous groups at the same hierarchical level (Putnam, 2000). By contrast, 'linking' social capital is a more recent conceptualization; it refers to the amount of trust between individuals and societal institutions across hierarchical levels (Szreter & Woolcock, 2004) and may be particularly relevant at the neighborhood level where the level of civic participation and the quality of local government could be important determinants of allocation and accessibility of resources (Sundquist et al., 2014). A recent study from Sweden showed that linking social capital, indicated by using neighborhood voting participation rates, was associated with reduced risk of elderly mortality, including suicide (Sundquist et al., 2014). Despite these previous studies, there continues to remain a paucity of related research.

Taipei City, Taiwan, provides a unique setting to investigate the spatial patterning and determinants of suicide. Taipei City is the capital and most densely populated city of Taiwan (Department of Statistics, 2010). Taipei not only has the highest average household income among all Taiwanese cities but also has the largest variation in household income (Fiscal Information Agency, 2014). The city is typical among emerging Asian cities for its rapid population growth and economic development (Liu & Tung, 2003); over the past four decades, its population more than tripled and the average disposable income per person increased 74%. A previous study showed large geographic variations and urban-rural differences in suicide across districts/townships (median population =27,000) in Taiwan in 1999-2007 (Chang et al., 2011). The study included the 12 districts of Taipei City (mean population ~ 200,000) and thus provided limited information about the detailed spatial patterning of suicide within the city. Furthermore, the study did not include potentially important social environmental factors such as income inequality and social capital as mentioned above.

The aim of this study was to investigate the spatial distribution and correlates of suicide across 432 neighborhoods in Taipei City. Specifically, we examined i) the spatial patterning of overall and sex/age-specific suicide rates, ii) their associations with a wide range of neighborhood socioeconomic characteristics including socioeconomic deprivation, social fragmentation, income inequality, and social capital, and iii) inequalities in suicide based on neighborhood economic circumstances.

2. Method

2.1 Suicide and population data

Mortality data files for suicide (2004-2010) for people aged 10 years and above in Taipei City were provided by the city government. The average annual age-standardized suicide rate (based on the World Health Organization's world standard population) in Taipei City was 11.8 per 100,000 population in 2004-2010, lower than 15.1 per 100,000 population in Taiwan as a whole over the same period (Taipei City Suicide Prevention Center, 2017). A previous study in Taiwan indicated that many deaths classified as undetermined death, accidental pesticide poisoning, or accidental suffocation were likely to be misclassified suicides (Chang et al., 2010). Therefore, we included all deaths certified as suicide (International Classification of Diseases, Tenth Revision [ICD-10] codes X60–X84), undetermined death (Y10-Y34), accidental pesticide poisoning (X48), or accidental suffocation (W75-W76, W83-W84) in our analyses. For simplicity, we used the term 'suicide' when referring to both certified suicides and deaths in the above alternative categories of death throughout the paper. To assess the impact of including potentially misclassified suicides on our findings, we conducted sensitivity analyses based on deaths certified as suicide only. Each suicide was assigned to one of 432 neighborhoods (or 'li', the smallest administrative level for which detailed population data were available) based on the registered residential address recorded in the mortality data files. In 2004-2010, the mean neighborhood population aged 10 years and above was 5,500 (range 840-31,300).

2.2 Data for neighborhood-level characteristics

Data on the following 16 neighborhood-level socioeconomic characteristics were extracted from the 2000 census (i-ix, xii-xiv, xvi), 2004-2010 Income Tax Statistics (x, xi), and the 2002 Election Report (xii). The variables were grouped into five domains:

a) indicators of social fragmentation: the proportions of i) single-person households; ii) people whose residences were different from those five years ago (an indicator of population mobility); iii) unmarried adults; iv) divorced/separated adults; and v) lone-parent households (i.e. households with a single, divorced, separated or widowed parent living with his/her unmarried child/children);
b) indicators of socioeconomic deprivation: the proportions of vi) households not-owner-occupied (i.e. households where the occupants did not own their house);

vii) overcrowded households (i.e. households with more than two people per room); viii) non-employed adults (i.e. people aged 15+ who were neither in paid employment nor in school); ix) population aged 15–17 not at school; x) median household income;

c) indicator of income inequality: xi) coefficient of variation in household income within the neighborhood;
d) indicator of linking social capital: xii) election participation (i.e. percent of eligible voters who turned out for the election);
e) other indicators: the proportions of xiii) population with limiting long-term illness; xiv) indigenous population; xv) agricultural workers; and xvi) population density (people per square kilometer).

These neighborhood-level characteristics were selected based on findings from previous research which showed associations between suicide and area-level social fragmentation (Congdon, 1996), socioeconomic disadvantage (Rehkopf & Buka, 2006), linking social capital (Sundquist et al., 2014), inequality (Machado et al., 2015), indigenous population (Liu et al., 2011), agricultural employment (Chang et al., 2012), and population density (Stark et al., 2007). Multicollinearity for the variables investigated was examined using the variance inflation factor (VIF). The VIFs of all the studied characteristics were lower than 10, indicating no evidence for multicollinearity (Kutner et al., 2004).

2.3 Statistical analysis

We calculated 'raw' (unsmoothed) standardized mortality ratios (SMRs) for suicide among people aged 10 years and above for each neighborhood during the period between 2004 and 2010. Expected deaths were calculated by multiplying the city-level sex-age-specific suicide rates by the corresponding sex-age-specific population years at risk in each neighborhood. SMRs for males and females aged 10–44 (early working age), 45–64 (late working age) and 65+ years (post-retirement) were also calculated separately. We used Spearman's correlation to examine the correlations between smoothed SMRs of different sex-age-groups.

Although data over the entire study period (2004–2010) were aggregated to ensure for sufficient suicides across neighborhoods, the relative rarity of suicide might still lead to unstable estimates of neighborhood SMRs (Lawson, 2013). Bayesian hierarchical models were thus used to estimate the 'smoothed' SMRs for each neighborhood and examine the associations of neighborhood-level socioeconomic characteristics with suicide. The model was based on the Poisson distribution and included both unstructured variability (i.e. heterogeneity among the whole study region) and structured variability (i.e. heterogeneity among the neighboring areas), thus taking into consideration the spatial autocorrelation between adjacent neighborhoods (Besag et al., 1991; Congdon, 1997). Adjacent neighborhoods were defined as those that shared a common border.

Associations with neighborhood-level characteristics were examined before and after adjusting for all other variables in multivariable Bayesian hierarchical models. Rate ratios (RRs) and their 95% credible intervals (CrIs) were estimated. We also estimated and mapped 'residual' SMRs after adjusting for all studied neighborhood variables to investigate the spatial patterning of variations which could not be explained by the studied variables. The probability for a residual SMR greater than one (i.e. above the average rate of the whole region) was also calculated and mapped. An additional model including only the unstructured variability but not the structured variability (i.e.

a ‘non-spatial’ model) and all the neighborhood variables studied was estimated to examine if the residuals were spatially correlated. Standardized values of neighborhood characteristics, or their log-transformed values when the distributions of raw values were skew, were used in the regression analyses. A binary variable for agricultural neighborhoods was derived from the percentage of the population employed in agriculture; the majority of neighborhoods had no agricultural workers (i.e. 0%) and thus a cut-off of 5% was then chosen (≥5% versus <5%). In a sensitivity analysis the median value (0.2%) was used as the cut-off and the results were similar. To investigate the socioeconomic inequalities in neighborhood suicide rates, we estimated RRs by quintile of median household income, using the quintile of the highest income as the reference group. Analyses were conducted for overall suicide and suicide by sex/age group.

Bayesian hierarchical models were estimated through Markov-Chain Monte Carlo methods (Gilks et al., 1996) in WinBUGS version 1.4 (David et al., 2003). The built-in conditional autoregressive distribution was used to incorporate spatially correlated components. We checked the convergence of models by visual inspection of three chains and through examination of the Gelman-Rubin diagnostic (Gelman, 2006) (see Appendix figure 1). All models were run for an initial ‘burn-in’ period of 10,000 iterations for the assessment of convergence. The three different chains with different initials were run for a further 7,500 iterations after reaching convergence, and the statistics of the posterior estimates were thus based on a total sample of 22,500 iterations pooled from all three chains. Non-informative prior distributions were used for the specifications of unstructured and structured variability in the Bayesian models. A sensitivity analysis using alternative priors was conducted to test the robustness of findings. The standard errors of unstructured and structured variability were specified using a uniform (0, 5) distribution in the main analysis (Gelman, 2006), and a gamma distribution (0.01, 0.01) was used for the inverse of the variance in the sensitivity analysis (Mollie, 2001).

To examine evidence for global spatial patterning of suicide rates, we considered the different population sizes across areas and calculated Moran's I statistics using GeoDa (Anselin et al., 2006). A value of zero was interpreted as indicating no spatial autocorrelation, while positive and negative values were interpreted as indicating positive or negative spatial autocorrelations, respectively (Moran's I could range from 1 to -1).

2.4 Mapping

Raw and smoothed SMRs for suicide were mapped using seven category breaks that are symmetrical on the logarithmic scale (<0.5, 0.5–0.65, >0.65–0.9, >0.9–1.1, >1.1–1.56, >1.56–2.0 and >2.0) with a divergent red–blue color scheme (Brewer, 1996). When calculating SMRs we used the whole study region as the reference group; thus a value of one indicates a level equal to the whole city average and is included in the middle category (SMR=0.9-1.1). Red and blue with varying hues were used to demonstrate categories with values higher (red) and lower (blue) than the middle category (white).

We also used the cartogram to depict the geographic distribution of the suicide burden. On a regular map, more densely populated areas often appear small in size compared to less densely populated areas, which may appear over-represented on the map and disproportionately draw the readers' attention (Sutherland, 1962). To address this issue, the cartogram renders the size of the area unit proportional to a designated parameter, e.g. population, for the purpose of achieving a uniform density map (Gastner & Newman, 2004). A cartogram can address the inaccurate visual impressions of regional data intensities shown on a regular map and help to reveal the actual burden of the outcome of interest. In this study we used the number of suicides as the parameter to rescale the size of area units so that the local burden of suicide could be highlighted. The cartogram was created using the Cartogram Geoprocessing Tool in ArcGIS. All maps were produced using ArcGIS Version 10.4.

3. Results

There were 3,012 suicides in people aged 10 years and above in Taipei City between 2004 and 2010; among them residential addresses were available for 2,994 (99.4%), which were included in the analysis. Of these 2,944 suicides (males 65.3%), there were 2,655 (88.7%) certified suicides, 323 (10.8%) undetermined deaths, 8 (0.3%) deaths classified as accidental pesticide poisoning, and 8 (0.3%) deaths classified as accidental suffocation. Among male suicides, 40.6% were 10-44 years old, 36.3% 45-64 years old, and 23.1% 65+ years old; the corresponding figures for female suicides were 42.5%, 35.2%, and 22.2%, respectively.

3.1 Spatial distributions and socioeconomic correlates of overall suicide rates

After excluding neighborhoods with no suicides (n=4, 0.9%), raw SMRs showed marked variations (range 0.12-4.62) and a 5.33-fold difference after excluding the 10% extreme values (mid-90% range 0.36-1.94). Smoothed SMRs ranged between 0.54-1.70 and a nearly two-fold difference in the mid-90% values (range 0.73-1.43) (Table 1). Moran's I was 0.17 ($p<0.001$), indicating evidence for spatial autocorrelation of suicide rates between neighboring areas (Table 1).

The geographic distribution of smoothed SMRs considering the statistical uncertainty in small-area suicide rates across the 432 neighborhoods is shown in Figure 1A. The central areas of Taipei City tended to show below average suicide rates, while above average suicide rates were found in some peripheral areas of the city. The top 10% of neighborhoods according to the level of suicide rates (smoothed SMRs > 1.30) accounted for only 8.8% of the total population of the city but 16.6% of overall suicides. When only certified suicides were mapped, the overall spatial patterning was similar (Appendix figure 2A). The sensitivity analysis using alternative priors in the Bayesian model also showed similar spatial patterning (Appendix figure 2B).

Figure 1B shows the cartogram of overall suicides, which highlights the actual burden of neighborhood suicide by rendering a neighborhood's size in proportion to its number of suicides. The central-peripheral pattern observed in Figure 1A remained in the cartogram. The areas with above average suicide rates in the west became markedly larger while those in the northeast, east, and south became markedly smaller; this indicates that the burden of suicide is concentrated in the western area of Taipei, which has a larger population, higher population density, and higher suicide rate than other areas.

Table 2 presents the associations between suicide rate and neighborhood-level socioeconomic characteristics. In the unadjusted models, 10 out of the 16 characteristics investigated were associated with suicide. Overall, suicide rates were positively associated with social fragmentation (e.g. a higher proportion of single-person households and divorced/separated adults), socioeconomic deprivation (e.g. a lower median household income or higher proportion of not-owner-occupied households), low social capital (indicated by low election participation), and the proportion of indigenous population. Of note, there was no evidence for an association of suicide with income inequality. After controlling for all other variables, the strength of most associations was attenuated. However, there was still evidence for an association (i.e. the 95% credible intervals did not include one) of suicide rates with the proportion of divorced/separated adults (RR=1.08, 95% CrI=1.01–1.16) and median household income (RR=0.80, 95% CrI=0.73–0.86). The sensitivity analysis used alternative priors showed similar findings (Appendix table 1). The spatial distributions of these two area characteristics are shown in Appendix figure 3.

These neighborhood socioeconomic characteristics explained 60.1% of the variation in area suicide rates based on comparing the estimates of geographic variability in the constant-only models and the fully adjusted models that included all investigated socioeconomic characteristics. Figure 1C presents the map of residual SMRs after taking into account all studied variables. There was still a 1.3-fold difference in the mid-90% range of SMRs (0.87–1.15). Compared with the smoothed map (Figure 1A), the spatial concentration of high and low risk areas attenuated somewhat in the residual map, indicating that the spatial patterning of suicide can be explained to some extent by the neighborhood variables investigated. However, pockets of low suicide rate areas were still mainly seen in the central region of the city, with some concentration of above average suicide rates in the southwestern and southern areas. The map of posterior probability of the residual SMRs greater than one showed that the evidence for above average residual rate was the greatest in the southwestern area (Appendix figure 4). Residuals derived from the 'non-spatial' model showed that there was still evidence for spatial autocorrelation after accounting for all neighborhood variables studied (Moran's I = 0.06; p=0.019), indicating the evidence for some underlying spatial pattering of suicide in the city.

3.2 Spatial distributions and socioeconomic correlates of sex-age-specific suicide rates

Figure 2 shows the maps of sex-age-specific smoothed SMRs for suicide. The 'central-peripheral' contrast in suicide rates seen for overall suicides was generally found among males across age groups, and was especially marked in males aged 45-64 years. By contrast, the two younger female groups aged 10-44 and 45-64 years showed no clear evidence of the 'central-peripheral' pattern; females aged 65+ years showed similarly low suicide rates in the central region while higher rates in the north and south of the city. We examined the Spearman's correlations between smoothed SMRs of different sex-age-groups across neighborhoods (Appendix table 2). There was moderate correlation between the smoothed SMRs for males aged 10-44 and 45-64 (Spearman's correlation coefficient=0.59); in contrast, there were only very weak to weak correlations (0.04-0.26) between other age-specific groups in males and females.

Table 1 presents the distribution of smoothed SMRs and spatial autocorrelation by sex and age group. Males showed greater geographic variation in neighborhood smoothed SMRs than females; differences in the mid-90% values were 2.32-fold and 1.24-fold in males and females, respectively. Across sex-age groups, males aged 45-64 years showed the largest variations (3.02-fold difference) while females aged 10-44 years showed the smallest (1.30-fold difference). Similarly, the level of spatial clustering or autocorrelation was higher in males (Moran's I=0.15, $p<0.001$) than females (Moran's I=0.06, $p=0.02$), with males aged 45-64 years showing the highest level (Moran's I = 0.11, $p<0.001$) across sex/age groups. By contrast, there was no evidence for spatial clustering or autocorrelation in the two younger female groups aged 10-44 and 45-64 years.

Table 3 shows fully adjusted sex-age-specific results of the regression analyses. Median household income, which was associated with overall suicide rates, showed similar associations with male and female suicide rates in the two younger groups aged 10-44 and 45-64 years but not in the elderly group aged 65+ years. Of note, suicide rates for males aged 45-64 years were strongly and negatively associated with median household income (RR=0.68, 95% CrI 0.57-0.80). Neighborhood suicide rates in males aged 10-44, females aged 10-44, and females aged 45-64 years were additionally associated with non-schooling among people aged 15-17 years (positively), overcrowded households (negatively), and population mobility (positively) respectively. Elderly female suicide rates were associated with the proportion of unmarried adults (positively), not-owner-occupied households (negatively), and election participation (negatively).

3.3 Socioeconomic inequalities in suicide

Figure 3 shows suicide rate ratios by quintile of median household income. There was a marked gradient of increasing suicide rates with decreasing neighborhood median household income. Compared to the first (wealthiest) quintile of neighborhoods, suicide rate ratios were 1.3 (95% CrI=1.1–1.5), 1.4 (1.2–1.6), 1.6 (1.4–1.9), 1.8 (1.5–2.0) for the second to the fifth quintiles, respectively. Overall, the socioeconomic gradient in neighborhood suicide rates was more marked in males than females, and in younger groups than elderly groups. The socioeconomic gradient in suicide was most marked in males aged 45-64 years; in this group there was a 3.2-fold difference in suicide rates between the most deprived and the wealthiest quintiles.

4. Discussion

Our data showed a ‘central-peripheral’ pattern of suicide in Taipei City; there were below average suicide rates in the central areas and above average suicide rates in some peripheral areas of the city. Males of different age groups demonstrated similar geographic patterns to that of overall suicides, while there was no clear spatial pattern in younger females. Overall suicide rates were associated with indicators of both social fragmentation (i.e. proportion of divorced/separated adults) and socioeconomic deprivation (i.e. low median household income). Higher rates were found in neighborhoods with lower incomes, with males aged 45-64 years showing the largest gradient.

4.1 Strengths and limitations

Our study is among the few detailed investigations into the spatial patterning and correlates of suicide in a non-Western city. A wide range of neighborhood characteristics including social fragmentation, socioeconomic deprivation, income inequality, and social capital were examined, and analyses stratified by sex and age demonstrated subgroup-specific patterns. However, there are several limitations that need to be taken into consideration when interpreting the results of this study. This is an ecological study and the associations identified cannot be directly inferred at the individual level. The study design could not differentiate the contextual effect (i.e. the influence of area characteristics on individual suicide risk) from the compositional effect (i.e. the concentration of high-risk individuals that contributes to high local suicide rates). Data were aggregated across years (2004-2010) to ensure for a sufficient number of suicides in small areas. Any changes in the spatial patterning of suicide during the study period were not considered, and this may be further investigated using space-time models in future research (Helbich et al., 2017b). However, in this study, data for suicide and area characteristics were from different years and this may affect the association found; however the period for suicide data (2004-2010) postdated that for area characteristics (2000 or 2002), in line with the temporal sequence between the exposure and outcome of interest. We did not include some area characteristics such as the prevalence of mental disorders and the provision of mental health care for which data were not available. However, in the present study we focused on more 'upstream' socioeconomic variables that may influence local suicide rates. By contrast, the mental-health-related factors were more likely to be 'downstream' factors that might mediate some of the effects of upstream factors but would not confound the association of socioeconomic variables with suicide. Lastly, the studied area characteristics were not stratified by sex or age, which might somewhat limit the interpretability of findings in subgroups. However, some indicators, e.g. the proportion of non-schooling among people aged 15-17, may reflect the situation of specific age groups.

4.2 Spatial patterning of overall and sex-age-specific suicide

Our results showed a 'central-low and peripheral-high' pattern of suicide rates in Taipei City. A previous study from Taiwan at a much larger geographic scale (districts/townships; median population = 27,000) (Chang et al., 2011) than this study (neighborhoods; mean population = 5,500) could not reveal such a detailed spatial pattern. The finding from this study is in contrast to the pattern of high suicide rates in central, inner city areas found in London (Rezaeian et al., 2007), Amsterdam (Gotsens et al., 2013), Sydney (Burnley, 1994), and Hong Kong (Hsu et al., 2015). The difference in spatial patterning of suicide between Taipei City and other cities might be attributable to the difference in the geographic distribution of socioeconomic deprivation. The central areas were the most affluent region of Taipei City (see the map of the distribution of median household income in Appendix figure 3B). By contrast, the inner city areas tended to be the most socioeconomically deprived in other cities. Historically, the economic and administrative center of Taipei City moved from the western to the central area of the city. Change in the spatial patterning of suicide in relation to urban development merits further investigation. In London, a recent study showed that the 'bull's eye' pattern of increased suicide among young men in the city's central region gradually diminished between 1981-2005; however, the reasons underlying the change are unclear (Gunnell et al., 2012).

The cartogram presented a useful approach to mapping the distribution of suicide burden. Consistent with the regular map, the central-peripheral pattern remained in the cartogram; however, the pattern changed to show the prominence of one western area of the city in terms of not only the risk but also the burden of suicide. The cartogram could inform suicide prevention resource allocation by highlighting areas of heightened risk and burden. Although cartograms have been used previously in some health-related mapping research (Kronenfeld & Wong, 2017; Nakaya, 2010), few studies have used cartograms to investigate suicide. Further studies of suicide that utilize cartograms could be encouraged to investigate the geographic distribution of not only suicide risk but also suicide burden.

Our findings showed that males of different age groups, especially those aged 10-44 and 45-64 years, illustrated a similar spatial patterning of suicide to that of overall suicides with a 'central-low and peripheral-high' pattern, while females demonstrated much less consistent findings. Only several previous studies investigated sex and age-specific spatial patterns of suicide in cities (Hsu et al., 2015; Qi et al., 2010). One study from Queensland, Australia, found similar spatial patterns of suicide in males and females. However, detailed sex-age-specific patterns were less clear as many areas had no recorded suicides (Qi et al., 2010). Another recent spatial analysis of suicide from Hong Kong showed similar findings with those from the present study – the younger groups of males aged 10-44 and 45-64 years showed the largest spatial variations in suicide and similar spatial distributions to that of overall suicides, while their female counterparts showed no clear spatial patterning (Hsu et al., 2015). However, the sex/age differences in the spatial patterning of suicide should be interpreted with caution as the number of suicides was smaller in females than males and was very low or even zero among some age-specific groups of females in small areas, leading to less precise estimates of small-area suicide rates and greater uncertainty in the spatial patterns in females than males.

4.3 Neighborhood-level characteristics associated with suicide rates

Our data showed that indicators of social fragmentation and socioeconomic deprivation were both associated with suicide, in keeping with previous studies from Hong Kong (Hsu et al., 2015) and Seoul, South Korea (Yoon et al., 2015). When considering the relative explanatory power of characteristics representing social fragmentation and socioeconomic deprivation on suicide, our data appeared to suggest a stronger effect of deprivation than social fragmentation – every one standard deviation (SD) increase in median household income was associated with a 20% reduction in suicide rates while every one SD increase in the proportion of divorced/separated adults was associated with an 8% rise in suicide rates. In contrast, several previous ecological studies of suicide, mostly from the UK, tended to show that suicide was more strongly associated with social fragmentation than socioeconomic deprivation (Congdon, 1996; Evans et al., 2004; Middleton et al., 2004; Smith et al., 2001; Whitley et al., 1999). There are several possible explanations for the difference in findings between studies from Asian cities and UK studies. The Townsend deprivation index used in the UK studies includes several indirect indicators of socioeconomic deprivation and may underestimate the effect of deprivation on suicide compared to income, which was included in our analysis. Furthermore, social protection measures may be relatively more comprehensive in the UK than in Taiwan, Hong Kong, and South Korea, and may offset some of the suicide risk in the deprived population.

Our data showed that area suicide rates were not associated with income inequality across small areas. One small-area analysis of suicide from Hong Kong also found no evidence of an association between area suicide rates and income inequality (Hsu et al., 2015). Our study and the Hong Kong study used measures of income inequality at a small-area level; however, an individual's suicide risk may not be related to the local level of inequality, but the level of inequality on a larger geographic scale, as individuals' distress may not result from comparing themselves with others in the same neighborhood but rather others in a larger region. Nevertheless, in one recent study across Brazilian municipalities (90% have less than 50,000 inhabitants), there was evidence of a positive association of income inequality with municipalities' suicide rates (Machado et al., 2015). This suggests that both the geographic scale and context need to be considered when studying the effect of income inequality on suicide.

Some previous studies reported that social capital might protect against suicide (Okamoto et al., 2013; Smith & Kawachi, 2014). Our data showed that election participation, a proxy indicator of linking social capital, was associated with reduced suicide rates; however, the association was attenuated after adjusting for other area socioeconomic characteristics. In keeping with our findings, Kunst et al. (2013) found that the association of social capital indicators with area suicide rates was weakened considerably after adjusting for individual- and area-level factors. It is thus important to investigate the effect of social capital on suicide in the context of other important socioeconomic variables. Of note, in the adjusted analysis stratified by sex and age group, linking social capital was associated with suicide rates in females aged 65+ years. Another multi-level Swedish study, which measured social capital using neighborhood election participation, found that there was some weak evidence for an association of elderly suicide with linking social capital after adjusting for individual-level factors (Sundquist et al., 2014). Future research is needed to investigate whether social capital is specifically associated with suicide in the elderly population.

Our data showed that the associations of suicide with area socioeconomic characteristics varied across sex/age groups. One striking pattern was that the association of suicide with median household income was found only in non-elderly males and females. A recent systematic review of European studies indicated that the association between area-level socioeconomic disadvantage and suicidal behavior tended to be stronger in men than in women (Cairns et al., 2017). By contrast, our data showed age differences but not sex differences, suggesting that the sex/age moderation effect may vary by context. Two indicators of social fragmentation (i.e. population mobility and the proportion of unmarried adults) were associated with suicide rates in females aged 45-64 and 65+ years respectively, suggesting that social fragmentation may be more related to female than male suicide. However, previous studies showed no consistent pattern of sex difference in the association of suicide with social fragmentation (Chang et al., 2011; Hsu et al., 2015; Middleton et al., 2004).

4.4 Socioeconomic inequalities in suicide

Previous studies consistently showed a positive association of suicide rates with area-level socioeconomic deprivation (Cairns et al., 2017; Rehkopf & Buka, 2006). Based on small-area median household income, a recent study from Hong Kong showed a 2.3-fold difference in suicide rates between the wealthiest and the poorest quintiles (Hsu et al., 2015), compared to the 1.8-fold difference shown in our study. Another recent study from Seoul, South Korea showed a 1.4-fold difference in suicide rates between neighborhoods of the most and the least deprived quintiles based on a composite deprivation index (Yoon et al., 2015). However, the comparison was complicated by the differences in size of the small areas investigated and the deprivation indices used across studies.

Our data showed that the socioeconomic inequalities in suicide were more marked in males than females, in keeping with findings from several European cities (Cairns et al., 2017; Gotsens et al., 2013) and Hong Kong (Hsu et al., 2015). Furthermore, middle-aged males presented the strongest association compared with other sex/age groups, which supports the results reported by studies conducted in London (Rezaeian et al., 2007) and Hong Kong (Hsu et al., 2015). These findings suggest that men of working age are more susceptible to economic disadvantage than other groups and that middle-aged males living in deprived areas of the city are likely to be a high risk group for suicide.

4.5 Implications

Our findings showed that there were prominent spatial and socioeconomic inequalities in suicide in an Asian city that is typical in the region for its rapid economic development. This has implications for urban planning that takes into account the potential adverse impact of city development on citizen wellbeing and the segregation of vulnerability. There is a need for future research to better understand factors that are associated with changes in the geographic distribution of suicide over the process of urban development. The spatial analysis of suicide can be used to identify high risk areas for suicide prevention in cities. The gradient of socioeconomic inequality in suicide indicates a need for social and health policy that addresses socioeconomic disparities across all income groups, not only for the most deprived populations. Middle-aged men living in deprived areas in Taipei City should be classified as high risk and targeted for suicide prevention.

Conflicts of Interest

None.

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Figure captions

Figure 1. Maps of standardized mortality ratios (SMRs) for suicide across 432 neighborhoods in Taipei City, 2004-2010: (A) smoothed SMRs estimated using Bayesian hierarchical models; (B) a cartogram of smoothed SMRs weighted by suicides; and (C) residual SMRs after adjusting for 16 area socioeconomic characteristics.

Figure 2. Maps of smoothed standardized mortality ratios (SMRs) for suicide in males and females aged 10-44, 45-64, and 65+ years in Taipei City, 2004-2010.

Figure 3. Rate ratios of suicide associated with quintiles of decreasing levels in median household income by sex/age group in Taipei City, 2004-2010 (reference group: the quintile with highest median household income).

Figure

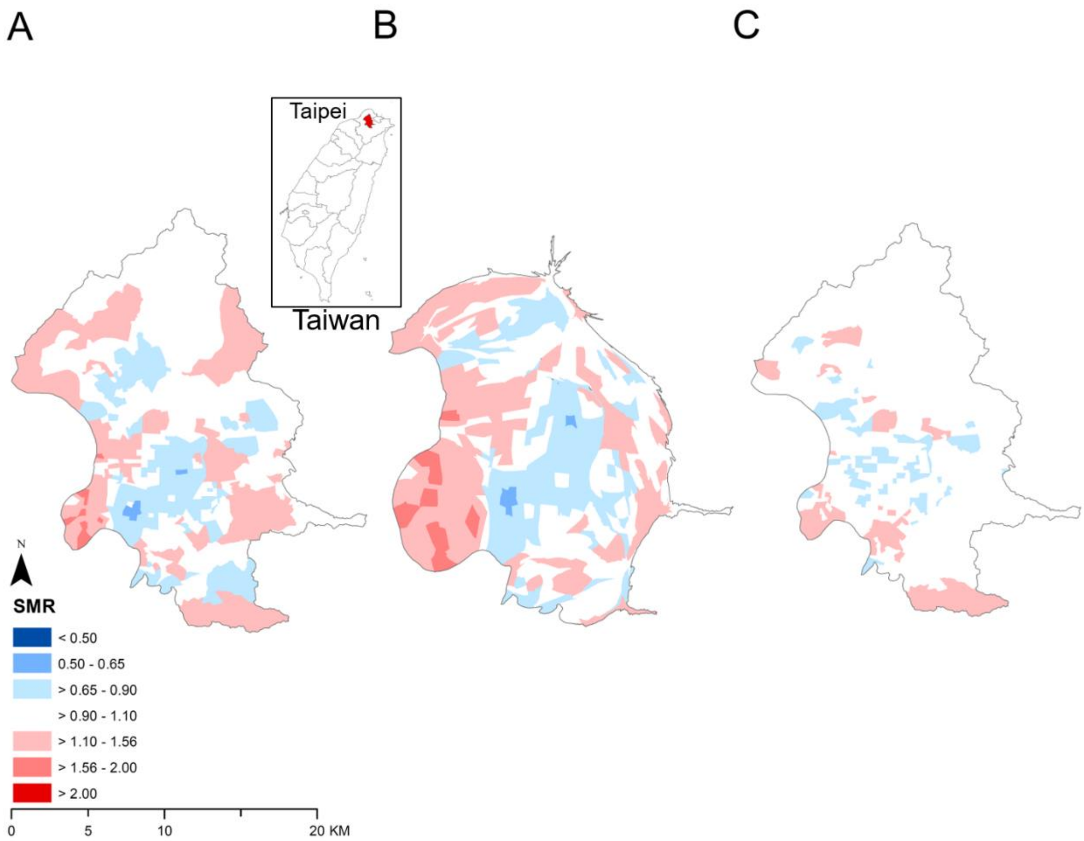


Figure 1. Maps of standardized mortality ratios (SMRs) for suicide across 432 neighborhoods in Taipei City, 2004–2010: (A) smoothed SMRs estimated using Bayesian hierarchical models, with an inset showing the location of Taipei City in Taiwan; (B) a cartogram in which the neighborhood size was proportional to the number of suicides; and (C) residual SMRs after adjusting for 16 area socioeconomic characteristics.

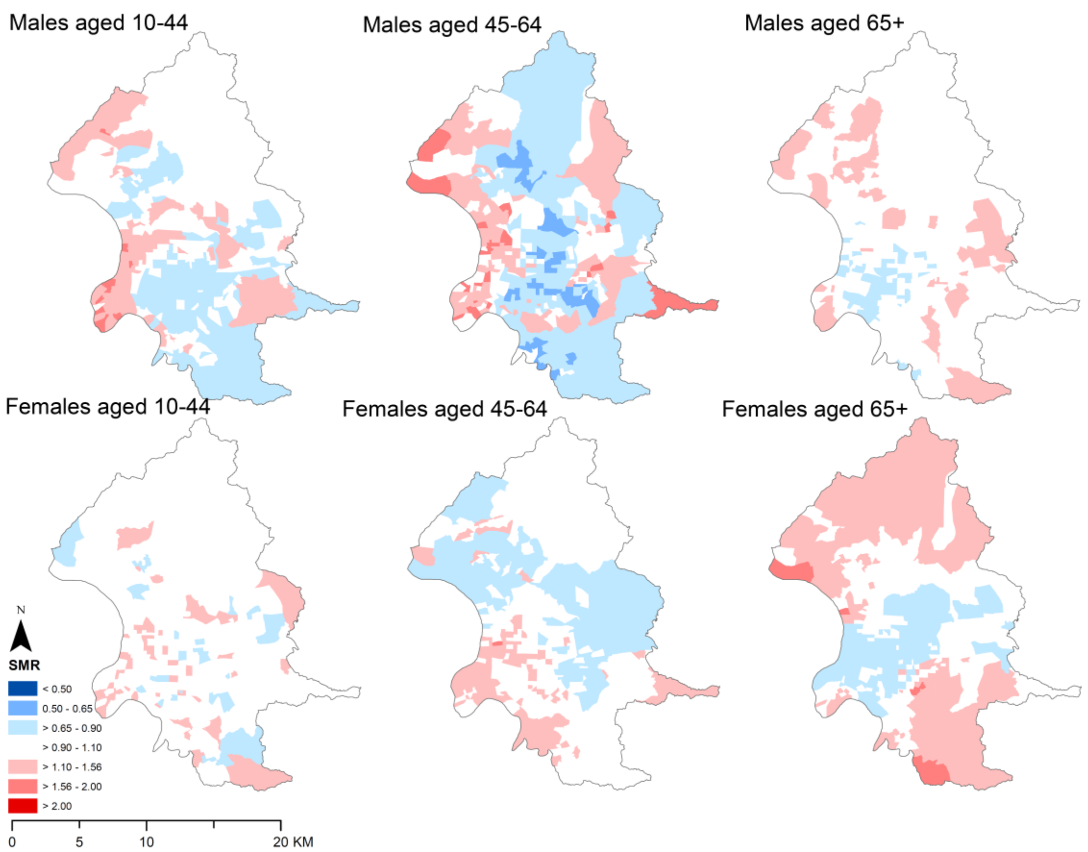


Figure 2. Maps of smoothed standardized mortality ratios (SMRs) for suicide in males and females aged 10-44, 45-64, and 65+ years in Taipei City, 2004–2010.

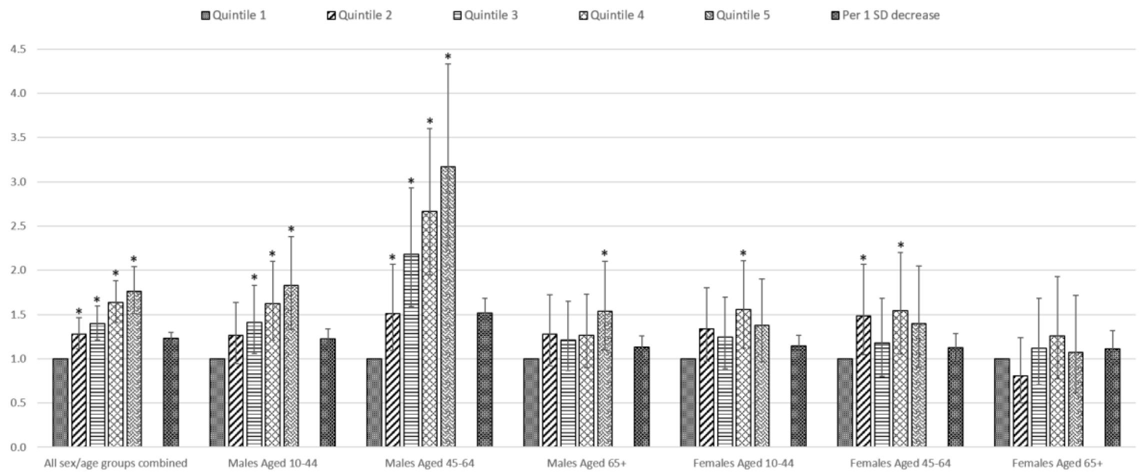


Figure 3. Rate ratios of suicide associated with quintiles of decreasing levels in median household income by sex/age group in Taipei City, 2004－2010 (reference group: the quintile with highest median household income).

* 95% credible intervals of rate ratios that do not include one are highlighted.

Table

Table 1. Summary statistics of the distribution of smoothed standardized mortality ratios (SMRs) for sex-age-specific suicide[a] across 432 neighborhoods in Taipei City, 2004-2010.

	Mean	SD	5%	Median	95%	90% ratio[b]	Moran's I	p value
All sex/age groups combined	1.01	0.21	0.73	0.97	1.43	1.95	0.17	<0.001
Males								
All ages combined	1.01	0.27	0.67	0.95	1.56	2.32	0.15	<0.001
Aged 10-44	1.00	0.25	0.71	0.95	1.47	2.07	0.06	0.02
Aged 45-64	1.03	0.41	0.59	0.93	1.79	3.02	0.11	<0.001
Aged 65+	1.00	0.10	0.86	0.99	1.21	1.40	0.04	<0.001
Females								
All ages combined	1.00	0.07	0.92	0.99	1.14	1.24	0.06	0.02
Aged 10-44	1.00	0.08	0.90	0.99	1.17	1.30	-0.01	0.34
Aged 45-64	1.01	0.17	0.79	0.99	1.29	1.63	0.00	0.50
Aged 65+	1.00	0.20	0.75	0.98	1.36	1.82	0.07	0.02

[a] Including deaths certified either as suicide, undetermined death, accidental suffocation or accidental pesticide poisoning.

[b] Differences over the 90% mid-range, i.e. the values at 95% divided by the values at 5%.

Table 2. Rate ratios (and 95% Credible Intervals) of suicide[a] in the population aged 10 years and above associated with one standard deviation increase in levels of each of the area socioeconomic characteristics across 432 neighborhoods in Taipei City, 2004–2010.

Area characteristics	Unadjusted			Adjusted for all other variables		
Social fragmentation						
Single-person households (%) [b]	**1.10**	**(1.05 ,**	**1.17)**	1.00	(0.94 ,	1.07)
Population mobility (%) [b]	1.01	(0.96 ,	1.06)	1.04	(0.98 ,	1.10)
Unmarried adults (%) [b]	**1.09**	**(1.04 ,**	**1.14)**	1.06	(0.98 ,	1.14)
Divorced/separated adults (%) [b]	**1.10**	**(1.05 ,**	**1.16)**	**1.08**	**(1.01 ,**	**1.16)**
Lone-parent households (%) [b]	**1.07**	**(1.01 ,**	**1.12)**	0.97	(0.91 ,	1.04)
Socioeconomic deprivation						
Not-owner-occupied households (%) [b]	**1.09**	**(1.03 ,**	**1.15)**	0.99	(0.92 ,	1.06)
Overcrowded households (%) [b]	**1.07**	**(1.01 ,**	**1.13)**	0.96	(0.90 ,	1.03)
Non-employed adults (%) [b]	1.00	(0.96 ,	1.05)	0.99	(0.91 ,	1.07)
Non-schooling among people aged 15-17 (%) [b]	**1.08**	**(1.03 ,**	**1.14)**	1.04	(0.99 ,	1.10)
Median household income [b]	**0.81**	**(0.77 ,**	**0.85)**	**0.80**	**(0.73 ,**	**0.86)**
Inequality: coefficient of variation in household income [b]	0.99	(0.94 ,	1.04)	1.03	(0.98 ,	1.09)
Social capital: election participation (%)	**0.95**	**(0.90 ,**	**0.99)**	0.96	(0.91 ,	1.01)
Others						
Population with limiting long-term illness (%) [b]	1.01	(0.97 ,	1.06)	0.98	(0.93 ,	1.04)
Indigenous people (%) [b]	**1.06**	**(1.01 ,**	**1.11)**	1.00	(0.95 ,	1.04)
Agricultural workers (≥5% versus <5%) [c]	1.31	(0.91 ,	1.83)	1.21	(0.82 ,	1.71)
Population density (people/km^2)	0.95	(0.90 ,	1.00)	0.99	(0.94 ,	1.03)

[a] Deaths certified as suicide, undetermined death or accidental pesticide poisoning/suffocation were all included.

[b] These variables were firstly log-transformed because of their skewed distributions.

[c] Except 'agricultural workers', which was a binary variable (≥5% versus <5%; the latter as the reference group).

[d] 95% credible intervals of rate ratios that do not include one are highlighted in bold.

Table 3. Rate ratios (and 95% Credible Intervals) of suicide[a] in males and females aged 10-44, 45-64, and 65+ years associated with one standard deviation increase in levels of each of the area socioeconomic characteristics after controlling for all other variable across 432 neighborhoods in Taipei City, 2004–2010.

Area characteristics	Males aged 10-44			Females aged 10-44		
Social fragmentation						
Single-person households (%) [b]	0.97	(0.86 ,	1.09)	1.06	(0.92 ,	1.23)
Population mobility (%) [b]	1.07	(0.96 ,	1.18)	0.95	(0.83 ,	1.09)
Unmarried adults (%) [b]	0.99	(0.85 ,	1.15)	0.85	(0.69 ,	1.02)
Divorced/separated adults (%) [b]	1.09	(0.95 ,	1.25)	1.08	(0.90 ,	1.28)
Lone-parent households (%) [b]	1.05	(0.91 ,	1.20)	0.98	(0.81 ,	1.16)
Socioeconomic deprivation						
Not-owner-occupied households (%) [b]	0.96	(0.84 ,	1.09)	1.06	(0.90 ,	1.25)
Overcrowded households (%) [b]	0.98	(0.85 ,	1.11)	**0.80**	**(0.68 ,**	**0.94)**
Non-employed adults (%) [b]	0.97	(0.81 ,	1.14)	0.87	(0.70 ,	1.07)
Non-schooling among people aged 15-17 (%) [b]	**1.13**	**(1.02 ,**	**1.26)**	1.13	(0.98 ,	1.28)
Median household income [b]	**0.82**	**(0.70 ,**	**0.96)**	**0.77**	**(0.63 ,**	**0.93)**
Inequality: coefficient of variation in household income [b]	1.06	(0.95 ,	1.16)	0.96	(0.85 ,	1.09)
Social capital: election participation (%)	1.01	(0.91 ,	1.12)	0.97	(0.87 ,	1.10)
Others						
Population with limiting long-term illness (%) [b]	1.07	(0.96 ,	1.18)	1.02	(0.89 ,	1.16)
Indigenous people (%) [b]	0.98	(0.89 ,	1.07)	0.98	(0.87 ,	1.09)
Agricultural workers (≥5% versus <5%) [c]	0.92	(0.41 ,	1.75)	1.23	(0.39 ,	2.70)
Population density (people/km^2)	0.94	(0.85 ,	1.03)	0.94	(0.83 ,	1.05)
	Males aged 45-64			Females aged 45-64		
Social fragmentation						
Single-person households (%) [b]	1.02	(0.91 ,	1.14)	1.09	(0.93 ,	1.26)
Population mobility (%) [b]	1.00	(0.89 ,	1.12)	**1.36**	**(1.18 ,**	**1.57)**
Unmarried adults (%) [b]	1.10	(0.95 ,	1.28)	1.06	(0.87 ,	1.28)
Divorced/separated adults (%) [b]	1.11	(0.96 ,	1.28)	1.06	(0.88 ,	1.26)
Lone-parent households (%) [b]	0.89	(0.77 ,	1.02)	0.99	(0.83 ,	1.19)
Socioeconomic deprivation						
Not-owner-occupied households (%) [b]	1.10	(0.95 ,	1.26)	0.98	(0.82 ,	1.18)
Overcrowded households (%) [b]	1.02	(0.88 ,	1.17)	1.05	(0.88 ,	1.25)
Non-employed adults (%) [b]	0.97	(0.81 ,	1.14)	0.97	(0.77 ,	1.19)
Non-schooling among people aged 15-17 (%) [b]	0.98	(0.88 ,	1.09)	0.92	(0.81 ,	1.06)
Median household income [b]	**0.68**	**(0.57 ,**	**0.80)**	**0.76**	**(0.61 ,**	**0.92)**
Inequality: coefficient of variation in household income [b]	0.94	(0.84 ,	1.05)	1.10	(0.97 ,	1.25)

Social capital: election participation (%)	1.06	(0.94 ,	1.21)	0.92	(0.82 ,	1.05)
Others						
Population with limiting long-term illness (%) [b]	0.95	(0.85 ,	1.05)	1.01	(0.88 ,	1.16)
Indigenous people (%) [b]	1.02	(0.92 ,	1.12)	0.91	(0.79 ,	1.03)
Agricultural workers (≥5% versus <5%) [c]	1.15	(0.51 ,	2.17)	2.06	(0.57 ,	4.84)
Population density (people/km^2)	1.04	(0.94 ,	1.14)	1.13	(0.99 ,	1.27)
	Males aged 65+			Females aged 65+		
Social fragmentation						
Single-person households (%) [b]	1.01	(0.87 ,	1.17)	0.88	(0.70 ,	1.11)
Population mobility (%) [b]	0.94	(0.82 ,	1.07)	1.02	(0.83 ,	1.22)
Unmarried adults (%) [b]	1.15	(0.97 ,	1.36)	**1.32**	**(1.00 ,**	**1.69)**
Divorced/separated adults (%) [b]	1.00	(0.85 ,	1.18)	1.23	(0.96 ,	1.57)
Lone-parent households (%) [b]	1.05	(0.89 ,	1.24)	0.92	(0.71 ,	1.17)
Socioeconomic deprivation						
Not-owner-occupied households (%) [b]	0.96	(0.82 ,	1.12)	**0.73**	**(0.58 ,**	**0.92)**
Overcrowded households (%) [b]	0.90	(0.76 ,	1.06)	1.11	(0.87 ,	1.40)
Non-employed adults (%) [b]	1.11	(0.93 ,	1.30)	1.11	(0.81 ,	1.46)
Non-schooling among people aged 15-17 (%) [b]	1.06	(0.93 ,	1.21)	1.01	(0.84 ,	1.21)
Median household income [b]	1.00	(0.75 ,	1.32)	1.10	(0.71 ,	1.63)
Inequality: coefficient of variation in household income [b]	1.03	(0.91 ,	1.16)	1.17	(0.99 ,	1.37)
Social capital: election participation (%)	0.93	(0.83 ,	1.04)	**0.87**	**(0.77 ,**	**0.99)**
Others						
Population with limiting long-term illness (%) [b]	0.93	(0.82 ,	1.05)	0.96	(0.80 ,	1.14)
Indigenous people (%) [b]	1.08	(0.96 ,	1.20)	0.92	(0.77 ,	1.08)
Agricultural workers (≥5% versus <5%) [c]	0.89	(0.29 ,	1.96)	1.42	(0.39 ,	3.46)
Population density (people/km^2)	0.96	(0.85 ,	1.07)	0.99	(0.84 ,	1.15)

[a] Deaths certified as suicide, undetermined death or accidental pesticide poisoning/suffocation were all included.

[b] These variables were firstly log-transformed because of their skewed distributions.

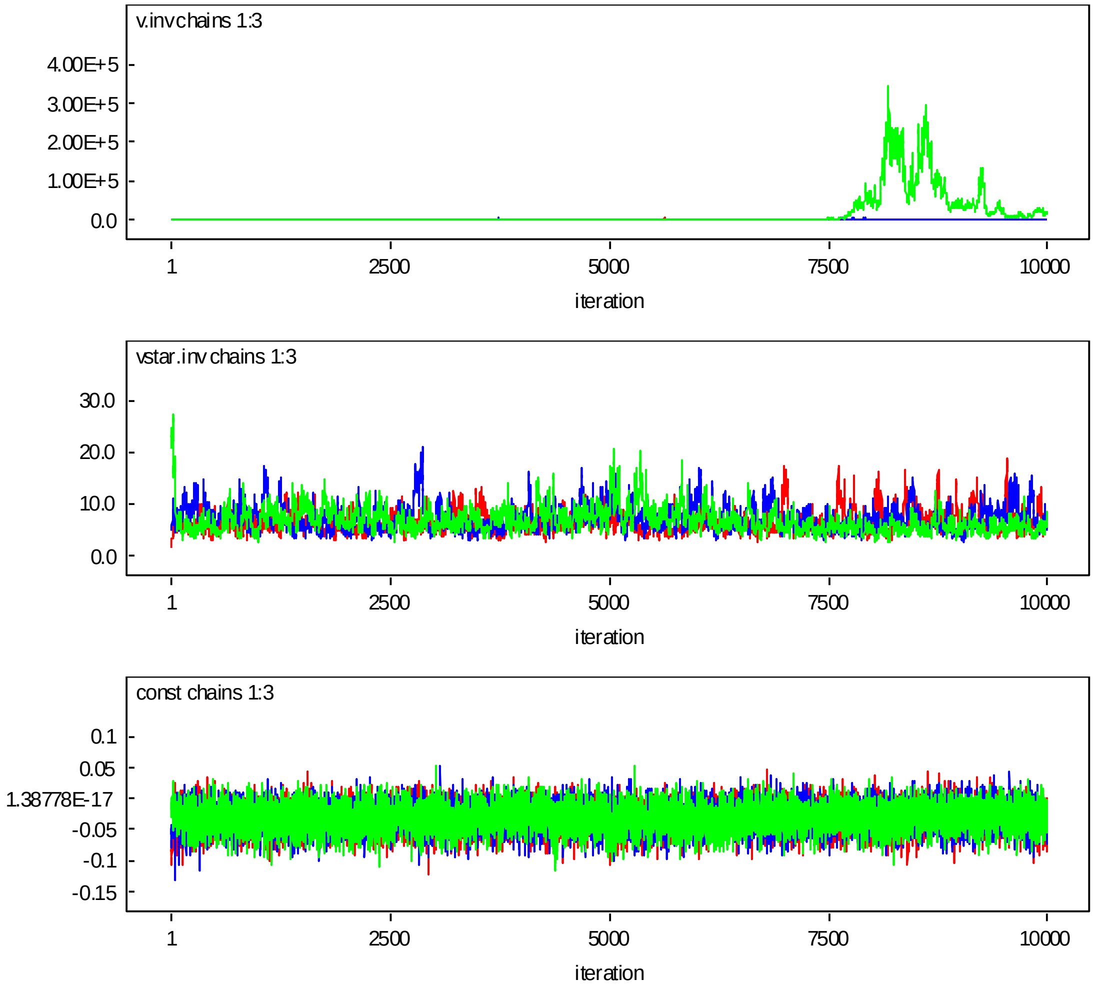
[c] Except ‘agricultural workers’, which was a binary variable (≥5% versus <5%; the latter as the reference group).

[d] 95% credible intervals of rate ratios that do not include one are highlighted in bold.

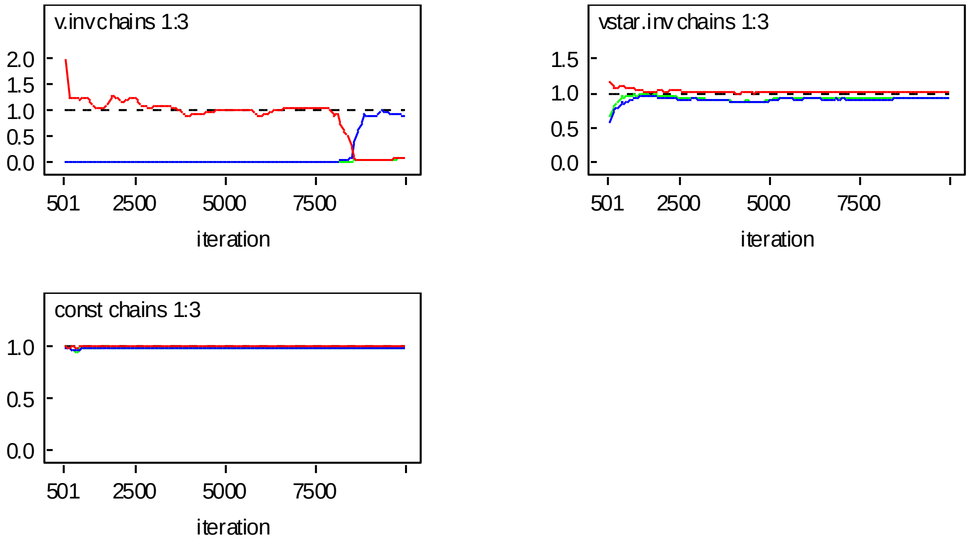
Appendix

Appendix figure 1. WinBUGS graphical outputs from the analyses for all sex/age groups combined.

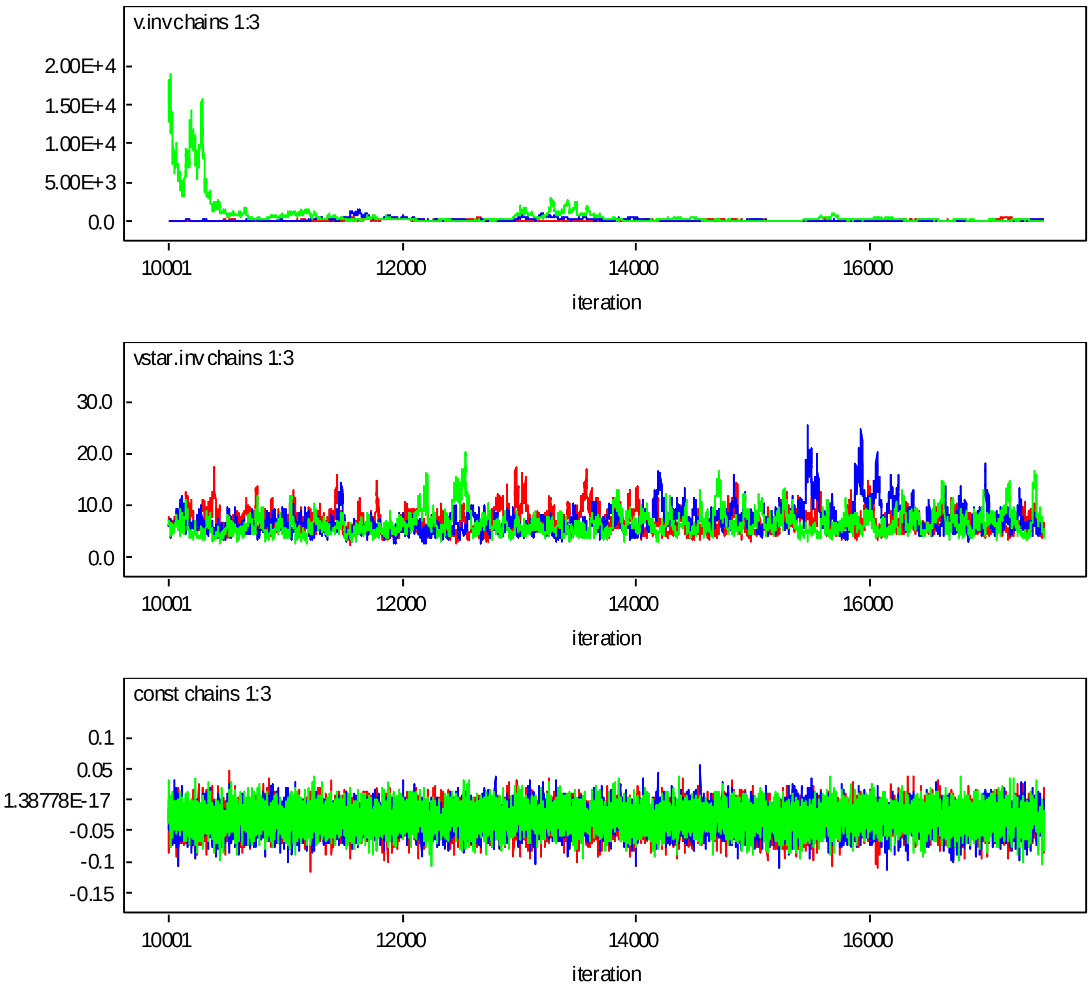
(a) Iteration history of the three chains for the inverse of the unstructured and structured variances (v.inv and vstar.inv) and the logarithm of the global mean (constant) in the burn-in period.



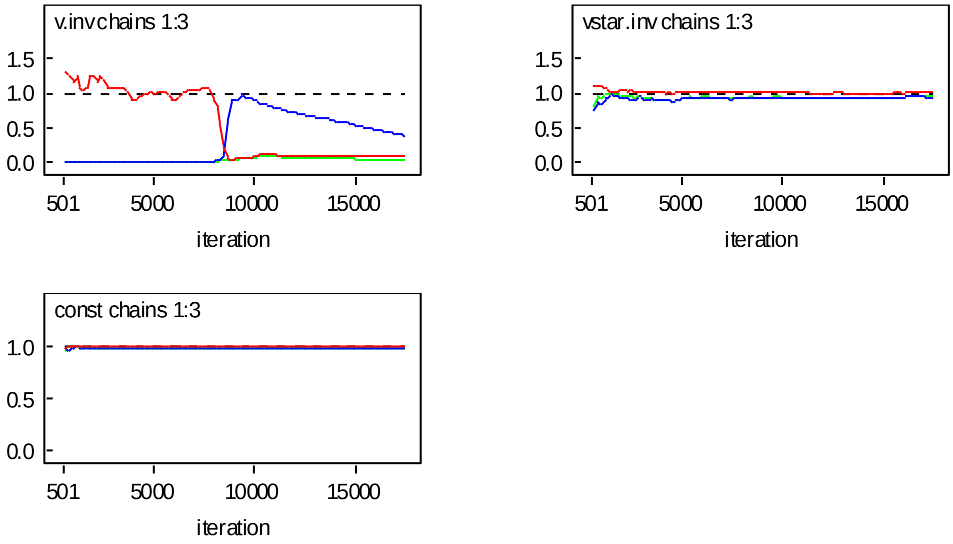
(b) Plots of the R-statistic for the inverse of the unstructured and structured variances (v.inv and vstar.inv) and the logarithm of the global mean (const) in the burn-in period.



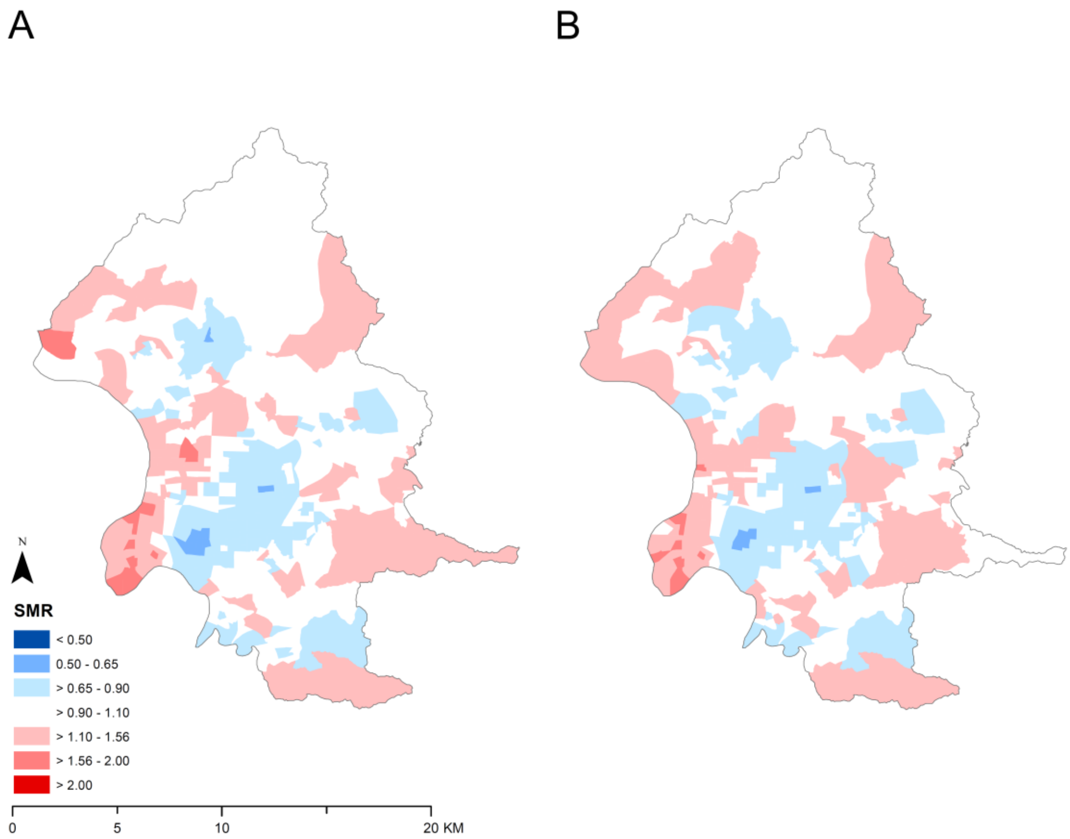
(c) Iteration history of the three chains for the inverse of the unstructured and structured variances (v.inv and vstar.inv) and the logarithm of the global mean (constant) after convergence.



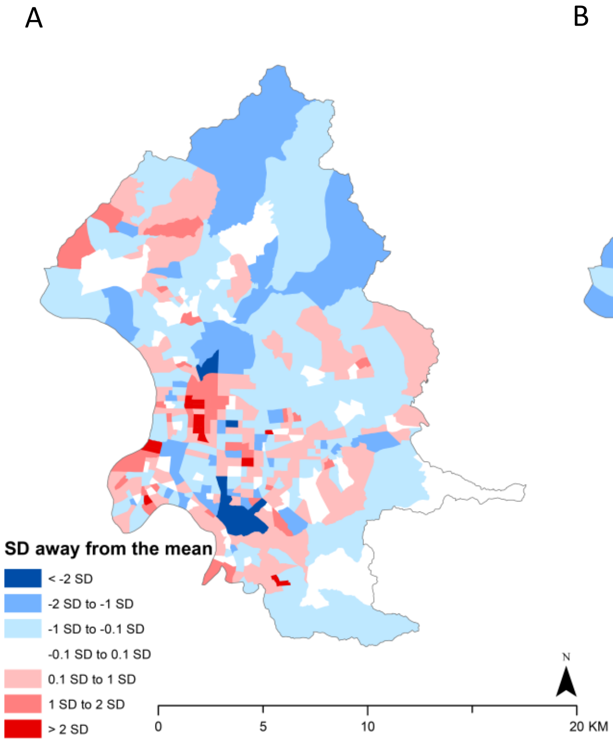
(d) Plots of the R-statistic for the inverse of the unstructured and structured variances (v.inv and vstar.inv) and the logarithm of the global mean (const) for the entire simulation.



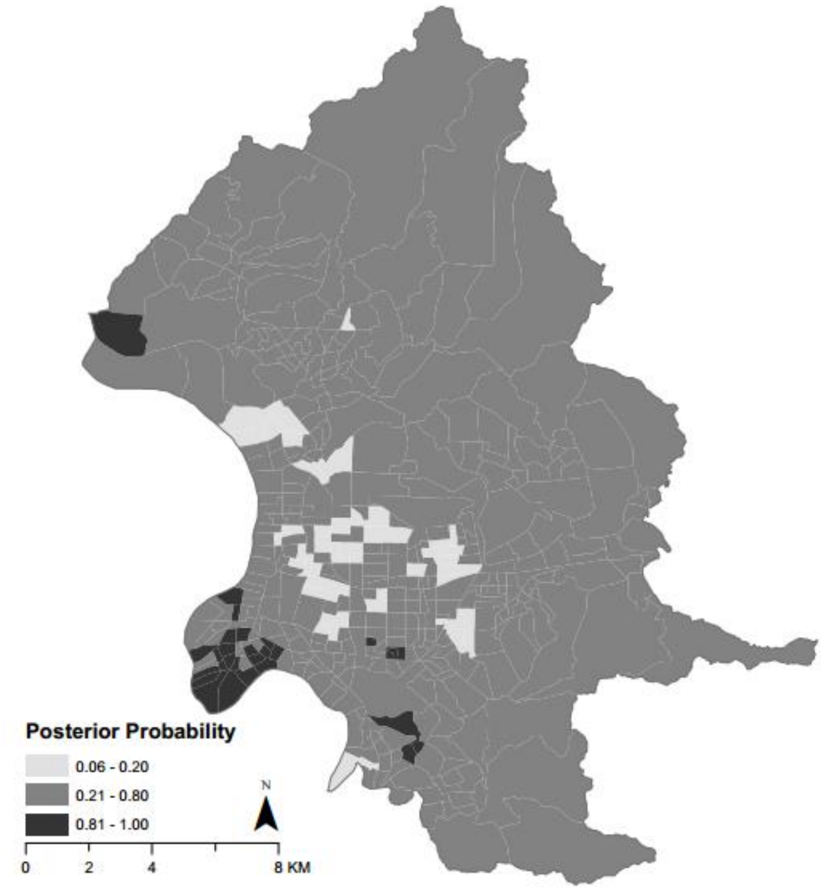
Appendix figure 2. Sensitivity analyses: maps of (A) smoothed standardized mortality ratios (SMRs) for certified suicide only and (B) smoothed SMRs estimated using Bayesian models with alternative priors in Taipei City, 2004–2010.



Appendix figure 3. Maps of (A) the proportion of divorced/separated adults; and (B) the median household income across 432 neighborhoods in Taipei City, 2004–2010.



Appendix figure 4. The map of posterior probability of the residual SMRs greater than one across 432 neighborhoods in Taipei City, 2004–2010.



Appendix table 1. Rate ratios (and 95% Credible Intervals) of suicide[a] in the population aged 10 years and above associated with one standard deviation increase in levels of each of the area socioeconomic characteristics across 432 neighborhoods in Taipei City, 2004–2010: sensitivity analysis using gamma distribution (0.01, 0.01) priors for the inverse of the variance of the unstructured and structured variability in the Bayesian hierarchical model.

Area characteristics	Main analysis			Sensitivity analysis		
Social fragmentation						
Single-person households (%) [b]	1.00	(0.94 ,	1.07)	1.00	(0.94 ,	1.06)
Population mobility (%) [b]	1.04	(0.98 ,	1.10)	1.04	(0.98 ,	1.10)
Unmarried adults (%) [b]	1.06	(0.98 ,	1.14)	1.06	(0.98 ,	1.14)
Divorced/separated adults (%) [b]	**1.08**	**(1.01 ,**	**1.16)**	**1.08**	**(1.01 ,**	**1.16)**
Lone-parent households (%) [b]	0.97	(0.91 ,	1.04)	0.98	(0.91 ,	1.05)
Socioeconomic deprivation						
Not-owner-occupied households (%) [b]	0.99	(0.92 ,	1.06)	0.98	(0.92 ,	1.05)
Overcrowded households (%) [b]	0.96	(0.90 ,	1.03)	0.96	(0.90 ,	1.03)
Non-employed adults (%) [b]	0.99	(0.91 ,	1.07)	1.00	(0.92 ,	1.08)
Non-schooling among people aged 15-17 (%) [b]	1.04	(0.99 ,	1.10)	1.04	(0.99 ,	1.10)
Median household income [b]	**0.80**	**(0.73 ,**	**0.86)**	**0.80**	**(0.73 ,**	**0.87)**
Inequality: coefficient of variation in household income [b]	1.03	(0.98 ,	1.09)	1.03	(0.98 ,	1.09)
Social capital: election participation (%)	0.96	(0.91 ,	1.01)	0.96	(0.91 ,	1.01)
Others						
Population with limiting long-term illness (%) [b]	0.98	(0.93 ,	1.04)	0.98	(0.93 ,	1.04)
Indigenous people (%) [b]	1.00	(0.95 ,	1.04)	1.00	(0.95 ,	1.04)
Agricultural workers [c]	1.21	(0.82 ,	1.71)	1.21	(0.82 ,	1.70)
Population density (people/km^2)	0.99	(0.94 ,	1.03)	0.99	(0.94 ,	1.04)

[a] Including deaths certified either as suicide, undetermined death, accidental suffocation or accidental pesticide poisoning.

Appendix table 2. Spearman's correlations between the smoothed SMRs for suicide[a] for different sex-age-groups (aged 10+) across 432 neighborhoods in Taipei, 2004-2010.

	Males			**Females**		
	Aged 10-44	Aged 45-64	Aged 65+	Aged 10-44	Aged 45-64	Aged 65+
Males						
Aged 10-44	1					
Aged 45-64	0.59	1				
Aged 65+	0.26	0.16	1			
Females						
Aged 10-44	0.25	0.21	0.08	1		
Aged 45-64	0.23	0.12	-0.31	0.15	1	
Aged 65+	-0.10	-0.06	0.40	-0.04	-0.22	1

[a] Including deaths certified either as suicide, undetermined death, accidental suffocation, or accidental pesticide poisoning.